NASA CONTRACTOR REPORT

NASA CR-179

NASA CR-179

FACILITY FORM 602

N65 18502 (ACCESSION NUMBER) (THRU)

37 (PAGES) / (CODE)

(NASA CR OR TMX OR AD NUMBER) 04 (CATEGORY)

GPO PRICE $ ____

OTS PRICE(S) $ ____

Hard copy (HC) ____

Microfiche (MF) ____

THE EFFECT OF BEDREST ON VARIOUS PARAMETERS OF PHYSIOLOGICAL FUNCTION

PART IX. THE EFFECT ON THE VITAL SIGNS AND CIRCULATORY DYNAMICS

by C. Vallbona, W. A. Spencer, F. B. Vogt, and D. Cardus

Prepared under Contract No. NAS 9-1461 *by*
TEXAS INSTITUTE FOR REHABILITATION AND RESEARCH
Houston, Texas
for

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION • WASHINGTON, D. C. • MARCH 1965

NASA CR-179

THE EFFECT OF BEDREST ON VARIOUS PARAMETERS OF PHYSIOLOGICAL FUNCTION

PART IX. THE EFFECT ON THE VITAL SIGNS AND CIRCULATORY DYNAMICS

By C. Vallbona, W. A. Spencer, F. B. Vogt, and D. Cardus

Prepared under Contract No. NAS 9-1461 by
TEXAS INSTITUTE FOR REHABILITATION AND RESEARCH
Houston, Texas

for

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

For sale by the Office of Technical Services, Department of Commerce,
Washington, D.C. 20230 -- Price $2.00

THE EFFECT OF BEDREST ON VARIOUS PARAMETERS OF PHYSIOLOGICAL FUNCTION

PART IX. THE EFFECT ON THE VITAL SIGNS AND CIRCULATORY DYNAMICS

By C. Vallbona, M.D., W. A. Spencer, M.D., F. B. Vogt, M. D.,

and D. Cardus, M. D.

ABSTRACT

18502

This study was carried out to evaluate if periods of 3 days and of 14 days of bedrest would produce changes in the vital signs and in the duration of phases of the cardiac cycle. The results of 3 days indicated no obvious signs of circulatory "deconditioning". When bedrest lasted 14 days, there was a trend for the blood pressure to increase throughout confinement. Circadian rhythms in the cardiac dynamics were detected. The values of the systolic and isotonic ratios and of the pulse wave velocity suggest a slight degree of stress under the conditions of the experiment. A program of isometric exercises during bedrest caused cardiodynamic changes which are strongly suggestive of greater stress.

Author

FOREWORD

This study is a part of a NASA investigation of the effect of bedrest on various parameters of physiological function. It was sponsored by NASA Manned Spacecraft Center under Contract NAS-9-1461, with Dr. Lawrence F. Dietlein, Chief, Space Medicine Branch, serving as Technical Monitor.

This study was conducted in the Immobilization Study Unit of the Texas Institute for Rehabilitation and Research, The Texas Medical Center. The authors are affiliated with Baylor University College of Medicine as follows: Dr. Vallbona, Departments of Rehabilitation, Physiology, and Pediatrics; Dr. Spencer, Department of Rehabilitation; Dr. Vogt, Department of Rehabilitation; and Dr. Cardus, Departments of Rehabilitation and Physiology.

The authors wish to express their appreciation to the medical and nursing staff of the Texas Institute for Rehabilitation and Research for their assistance in providing full time surveillance of the subjects during these experiments. A special acknowledgement is made of Dr. H. E. Hoff's contributions to these studies and to the preparation of the report. Credit is given also to Mr. R. Lamonte and Mr. J. McConnell, Bioinstrumentation Section, Space Medicine Branch, Manned Spacecraft Center, NASA, for the installation and maintenance of the monitoring equipment; to Mrs. A. Goldstein and Mr. T. O. Townsend for their part in the monitoring of the subjects; to Mrs. D. Bellis, Mr. W. Fedderson, and Miss M. E. Oro for the digitation of the analogue records; to Mr. F. Rosenbaum for the computer programming of the initial calculations and plotting of data; to Messrs. W. Blose and H. Thompson for the statistical analyses; to Dr. M. T. de Caralt for the preparation of graphs ; and to Miss S. Beggs, Mrs. L. Shropshire, and Mr. T. Allen for the editing and preparation of the report.

THE EFFECT OF BEDREST ON VARIOUS PARAMETERS OF PHYSIOLOGICAL FUNCTION

PART IX. THE EFFECT ON THE VITAL SIGNS AND CIRCULATORY DYNAMICS

By C. Vallbona, M.D., W. A. Spencer, M.D., F. B. Vogt, M. D.,

and D. Cardus, M. D.

SUMMARY

This study was carried out to evaluate if short term (3 days) and long term (14 days) bedrest would produce changes in the vital signs as well as in the duration of the cardiac cycle and its phases. A program of isometric exercises during bedrest was also evaluated to see if it would offset the possible cardiovascular effects of recumbency.

The results of this study showed that there were no obvious signs of circulatory "deconditioning" when bedrest lasted for 72 hours. There were circadian fluctuations in the duration of the various phases of the cardiac cycle, and it was concluded that under the conditions of this study the subjects were slightly under stress. This was more manifest in the second period of the study when a program of isometric exercises was introduced as an added variable. When bedrest was prolonged for a total of 14 days, the observations were in agreement with those of the first study, although there was a trend for the blood pressure to increase throughout the period of confinement. Circadian rhythms in the cardiac dynamics were also detected. The values of the systolic and isotonic ratios and of the pulse wave velocity suggest a slight degree of stress under the conditions of the experiment. The introduction of a program of isometric exercises during confinement to bed produced also changes in cardiac dynamics which are strongly suggestive to a greater reaction of stress.

INTRODUCTION

Previous studies have shown that bedrest may produce a decrease in the mean arterial blood pressure and an increase in the heart rate.[1,2] This effect is more pronounced and occurs more rapidly in individuals submerged in water.[3,4]

Raab and co-workers[5] have demonstrated that a program of physical training changes considerably the duration of the cardiac cycle and its phases. Raab indicates that the changes reflect a cholinergic effect that results in prolongation of the isometric phase of the contraction and a decrease in the resting heart rate. Prolonged bedrest may produce an effect opposite to physical training, and from a theoretical standpoint it would result in a shortening of the isometric phase of the contraction and an over-all shortening of the duration of the mechanical systole. These are changes observed under the influence of epinephrine,[5,6] and they are considered manifestations of an adrenergic reaction.

The purpose of this report is to present the results of experiments performed to evaluate if a physiological effect of bedrest would be manifested by changes in the vital signs as well as in the duration of the cardiac cycle and its phases. A program of isometric exercises during bedrest was also evaluated to see if it would offset the possible cardiovascular effects of recumbency.

METHOD

A. Subjects

A total of thirteen healthy subjects participated in these studies. Their physical characteristics are summarized in Table 1. Six subjects participated in the first study which included two periods of three days of bedrest. Another group of seven men participated in the second study which included two periods of 14 days of bedrest. Five men took part in both periods of this second study; one participated in the first only and was replaced in the second period. One subject who participated in both periods of this second study requested dismissal at the end of 13 days because he was asked to return home for an emergency.

The second period of bedrest of each study had exactly the same experimental conditions as the first, with the exception of a program of isometric exercise which was carried out in the supine position.

B. Experimental conditions

The six subjects who participated in the first study (Study I) were admitted to the Immobilization Research Center at the Texas Institute for Rehabilitation and Research on April 30, 1963 and were kept under observation for a period of five days. The subjects slept and had their meals in the hospital. They were on a diet of 100 grams of protein, 1000 milligrams of calcium, and 2300 calories. Intake and output were carefully recorded. The subjects drank as much distilled water as they wished. After these days of observation, they remained in bed for three days. They were allowed to move freely in the horizontal position but were under constant

TABLE 1

SUBJECTS PARTICIPATING IN STUDY I
TWO PERIODS OF THREE DAYS OF BEDREST

TIRR Subject No.	Name	Age (years)	Height (centimeters)	Weight (kilograms)	Body Surface Area (m^2)	Usual Occupation
70-0-01	RKW	27	183.0	81.8	2.04	Newswriter
70-0-06	CBB	39	177.8	75.0	1.92	Oil refinery process operator (on strike)
70-0-07	RNM	21	177.8	72.7	1.90	Clerk
70-0-08	WRS	21	190.5	75.0	2.02	Student
70-0-09	THL	37	180.4	78.1	1.98	Oil refinery process operator (on strike)
70-0-10	RGW	40	175.2	76.8	1.92	Oil refinery process operator (on strike)

SUBJECTS PARTICIPATING IN STUDY II
TWO PERIODS OF FOURTEEN DAYS OF BEDREST

70-0-11	ACL	33	170.3	62.7	1.73	Student (athlete)
70-0-12	TGO*	21	188.0	79.2	2.06	Student
70-0-13	MGO	24	177.8	79.2	1.97	Student (athlete)
70-0-14	DC	24	180.4	75.0	1.94	Student
70-0-16	CLB**	24	185.5	85.7	2.10	Student counselor
70-0-17	CP	34	180.4	77.0	1.97	School teacher
70-0-18	ACI***	22	165.0	50.0	1.54	Student (athlete)

* Participated in first period only (fourteen days of bedrest)

** Had to be dismissed on the thirteenth day of bedrest of the second period

*** Participated in second period only (fourteen days of bedrest with isometric exercise) surveillance to prevent the raising of their legs or trunk above the horizontal position. They were allowed one pillow under the head. Meals and emunctory functions were performed in the horizontal position. Following this first period of bedrest the subjects were kept under observation for an additional three days; they were on the same diet and the same conditions existed as before bedrest. The subjects were dismissed on May 11, 1963. They were readmitted on May 15, 1963 and were kept under observation for five days; they were on the same diet and the same conditions existed as before the first period of bedrest. The second period of bedrest lasted three days also. It had the same characteristics as the first period with the exception of a program of isometric exercises that was carried out in the horizontal position four times a day at two hour intervals. Following bedrest, the subjects were in the hospital for an additional two days of observation.

The experimental conditions of the second study (Study II) were similar to those of the first with the following exceptions. The subjects remained under observation for seven days before bedrest and for four days after bedrest. The duration of bedrest was 14 days. The program of isometric exercises in the second period of Study II was carried out six times a day. Bedside monitoring during bedrest was less intensive in the second study. Hematologic and serum biochemical measurements were made less frequently.

C. Procedure

During the two periods of immobilization each subject had chronically applied electrodes for recording the electrocardiogram and the impedance pneumogram. The electrodes were the NASA Mercury type and were affixed to the skin by means of adhesive tape. Sensors for detecting carotid and radial pulses and heart sounds were attached to the subject prior to each period of monitoring. Arterial blood pressures were monitored by a cuff-microphone technique that was automatically cycled every 30 seconds. Electrodes and sensors were connected to signal conditioners in a mobile cabinet. The electrical signals were transmitted by a connecting cable to a central console where the physiological data were displayed on an oscilloscope and permanently recorded on magnetic tape. The minimum duration of the recordings was two minutes during each monitoring interval.

In the first study (three days of bedrest), monitoring began at 7 p.m. on May 6, 1963 and was repeated every four hours for three days. During the second period of immobilization, the first monitoring took place at 7 p.m. on May 20, 1963 and was repeated every four hours for three days. In the second study (fourteen days of bedrest), monitoring was done at less frequent intervals, but on the seventh and eighth days of the first period, the subjects were monitored every four hours. On most of the other days monitoring was done at intervals of 12 hours.

The oral temperatures of the subjects were measured by means of a clinical thermometer at 7 a.m. and 7 p.m. on the days of the second period of the three day study and each time of monitoring of the fourteen day study.

D. Analysis of data

The electrocardiogram, impedance pneumogram, arterial blood pressure, and cardiotachogram were played back from magnetic tape onto a rectilinear Physiograph-Six operated at a paper speed of 0.25 centimeters per second (first study) and on an Offner Dynograph recorder (second study). Determinations were made of the heart rate, respiratory rate, and systolic and diastolic blood pressures (every 30 seconds) for each subject during every session of monitoring. An average was obtained of all the measurements made on each subject at each session of monitoring.

The electrocardiogram, phonocardiogram, and carotid and radial pressure pulse recordings were played back on a CEC oscillograph recorder at a paper speed of 13.7 centimeters per second (first study) and on an Offner Dynograph recorder at a speed of 12.5 centimeters per second (second study). On each of 20 consecutive beats, digital readouts were made at the onset of the QRS, at the onset of the carotid pulse, at the onset of the radial pulse, at the onset of the second heart sound, and at the onset of the dicrotic notch. These digitized data permitted computation of the total duration of the mechanical systole, of the diastole, and of the isometric and isotonic phases of systole according to a method that has been proposed by numerous investigators.[7,8,9,10,11] Simultaneously, the pulse wave velocity was computed beat by beat from the measurements of the delay between the onset of the carotid and radial pressure pulse tracings and the measurement of the distance between the two sensors.[12]

In order to understand the significance of the changes in the duration of the phases of the cardiac cycle, it is necessary to take into consideration the variations that normally result with a change in cardiac frequency. An increase in heart rate causes a shortening of both the isotonic and isometric phases of systole and diastole. Since information is available on the quantitative relationship between increase in cardiac frequency and the shortening of the systole (and its isotonic and isometric phases), it is possible to calculate the extent of individual and group departures from this relationship throughout the period of study.* The observed-predicted systolic and isotonic ratios expressed the degree of these departures. The regression equation proposed by Hegglin[13,14] was used to predict the values of the duration of systole. The calculations of the predicted duration of the isotonic phase were based on the formula proposed by Blumberger.[15] The quotient duration of the isotonic phase / duration of the isometric phase has been referred to as the hemodynamic ratio,[16] and it has been found to decrease when

*This analytical treatment of the data had been suggested to us by Dr. O. Vogel in previous studies of the duration of systole in patients with poliomyelitis.

there is a drop in cardiac output.[5, 8, 9, 11, 16] It was possible to calculate this ratio in each subject since the duration of the isotonic and isometric phases of the contraction had been measured.

Statistical analysis of the vital signs and circulatory dynamics was carried out for the group of six subjects who participated in each period.

RESULTS

Table A1 gives the means and standard deviations of the values of vital signs for the group of six subjects at each period of monitoring.

Tables A2 and A3 show the means and standard deviations of the pulse wave velocity and of time intervals of the cardiac cycle for the group of six subjects at each period of monitoring.

Figures 1 and 2 show the changes in average values of vital signs throughout the periods of bedrest. The values of the periods of bedrest with isometric exercise are shown in red.

Figures 3 and 4 display the fluctuations in the systolic and isotonic ratios throughout the two studies. The values for the periods of bedrest with isometric exercise are shown in red.

Figures 5 and 6 present the plots of the average values of the duration of the cardiac cycle and its phases as they were actually measured throughout the first period of each study. The fluctuations depicted in these figures are greater than those of figures 3 and 4 because of the effects brought about by the changes in cardiac frequency.

A. Results of the first study (three days of bedrest).

The values of body temperature obtained in the second period of this study were always within normal limits and showed the expected circadian variations, with higher values in the evening hours. The failure to obtain temperature measurements in the first period precludes the establishment of any significant difference between the two periods.

The heart rate fluctuated very little throughout the two periods of recumbency. There were high values immediately after the first tilt in the first period, but the rate reached a steady state in 12 hours. The initial drop in cardiac frequency occurred also in the second period, but the starting values were not as high. The cardiotachometric tracings obtained in these individuals showed obvious fluctuations in the instantaneous heart rate. Some fluctuations showed a long periodicity; others seemed to occur at random; and in many instances, there

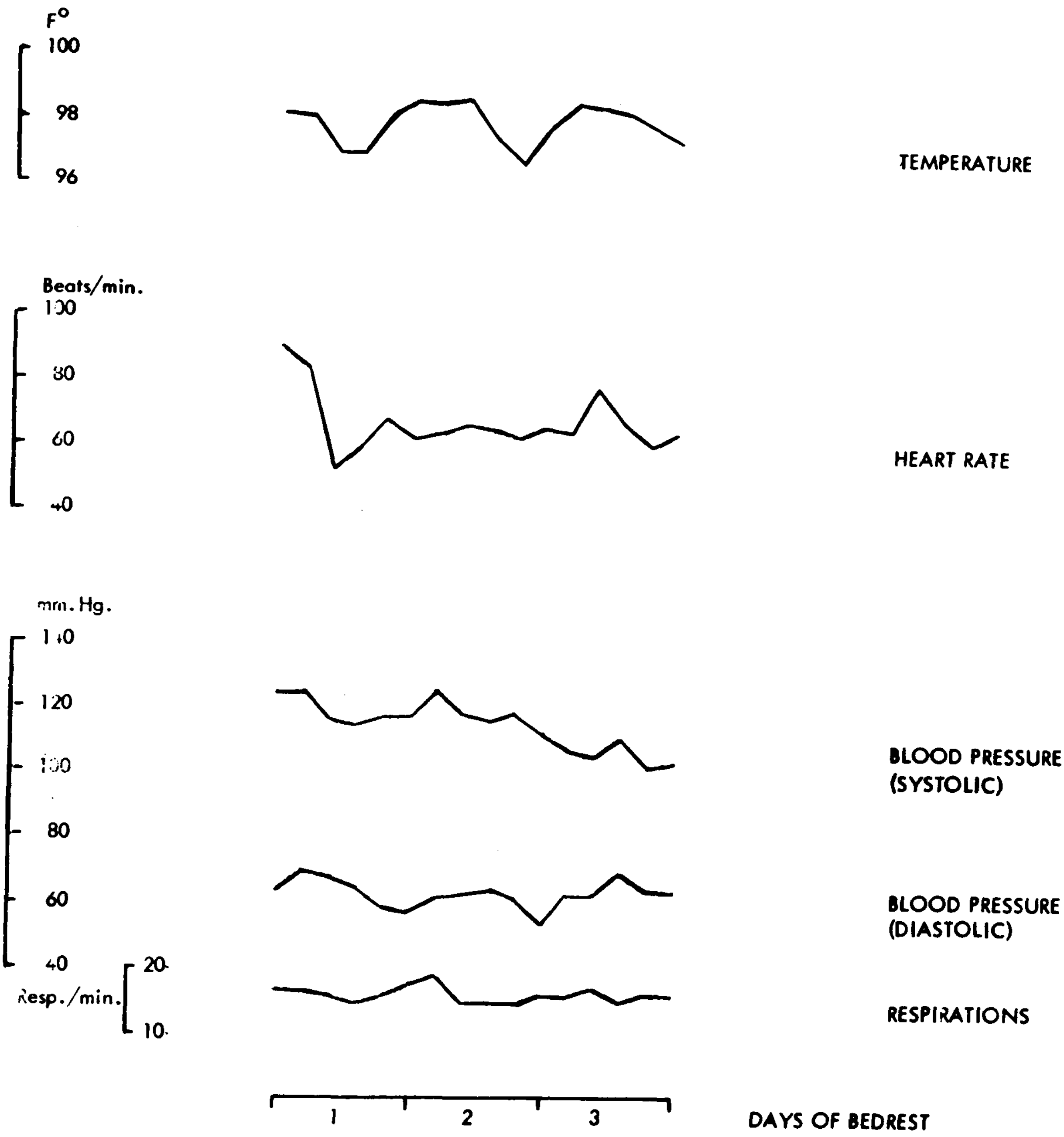

Figure 1

Average fluctuations of the vital signs during three days of bedrest (Study I Period 1)

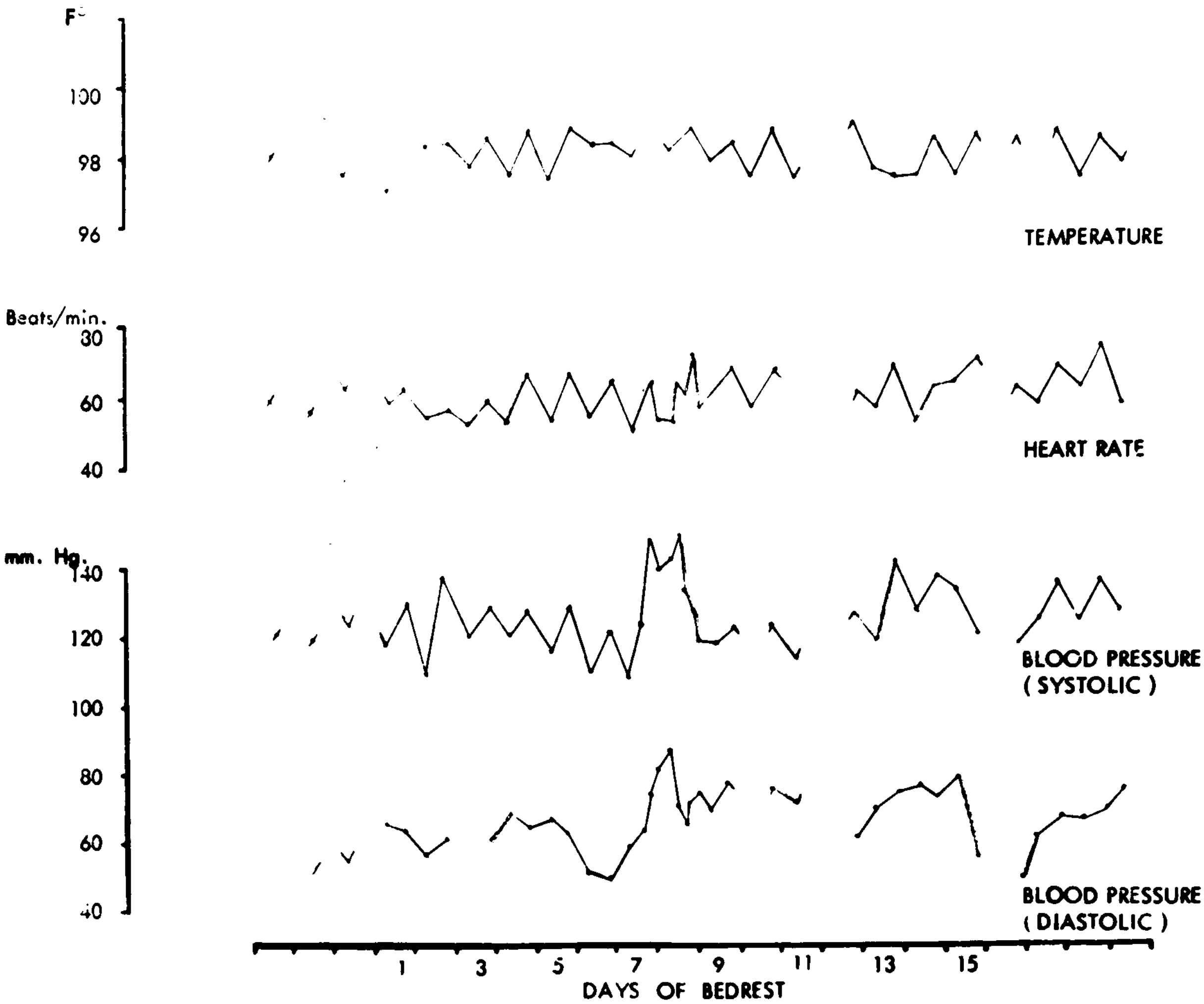

Figure 2

Average fluctuations of the vital signs during fourteen days of bedrest (StudyII Period 1)

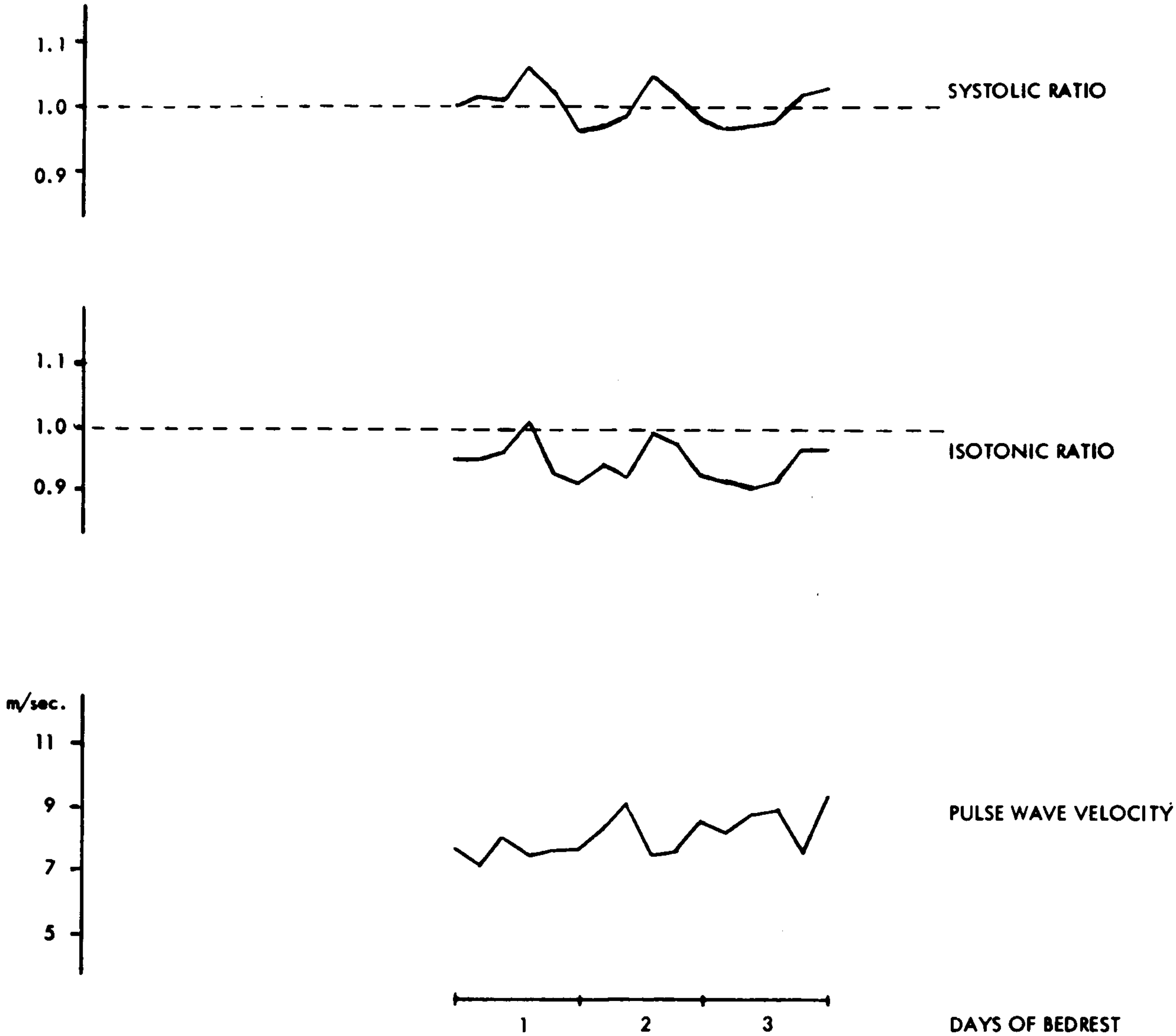

Figure 3

Average fluctuations of cardiac dynamics during three days of bedrest (Study I Period 1)

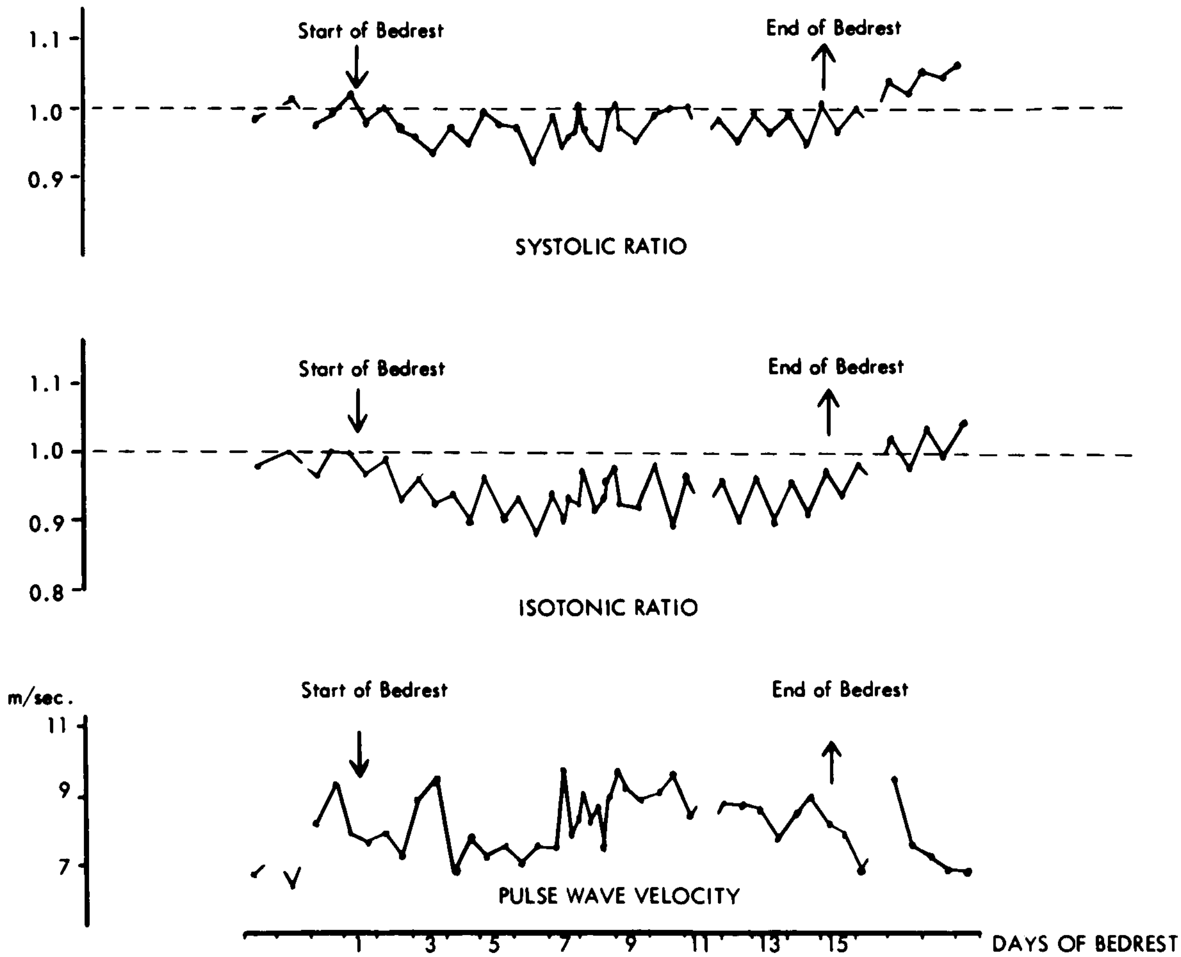

Figure 4

verage fluctuations of cardiac dynamics during fourteen days of bedrest (Study II Period 1)

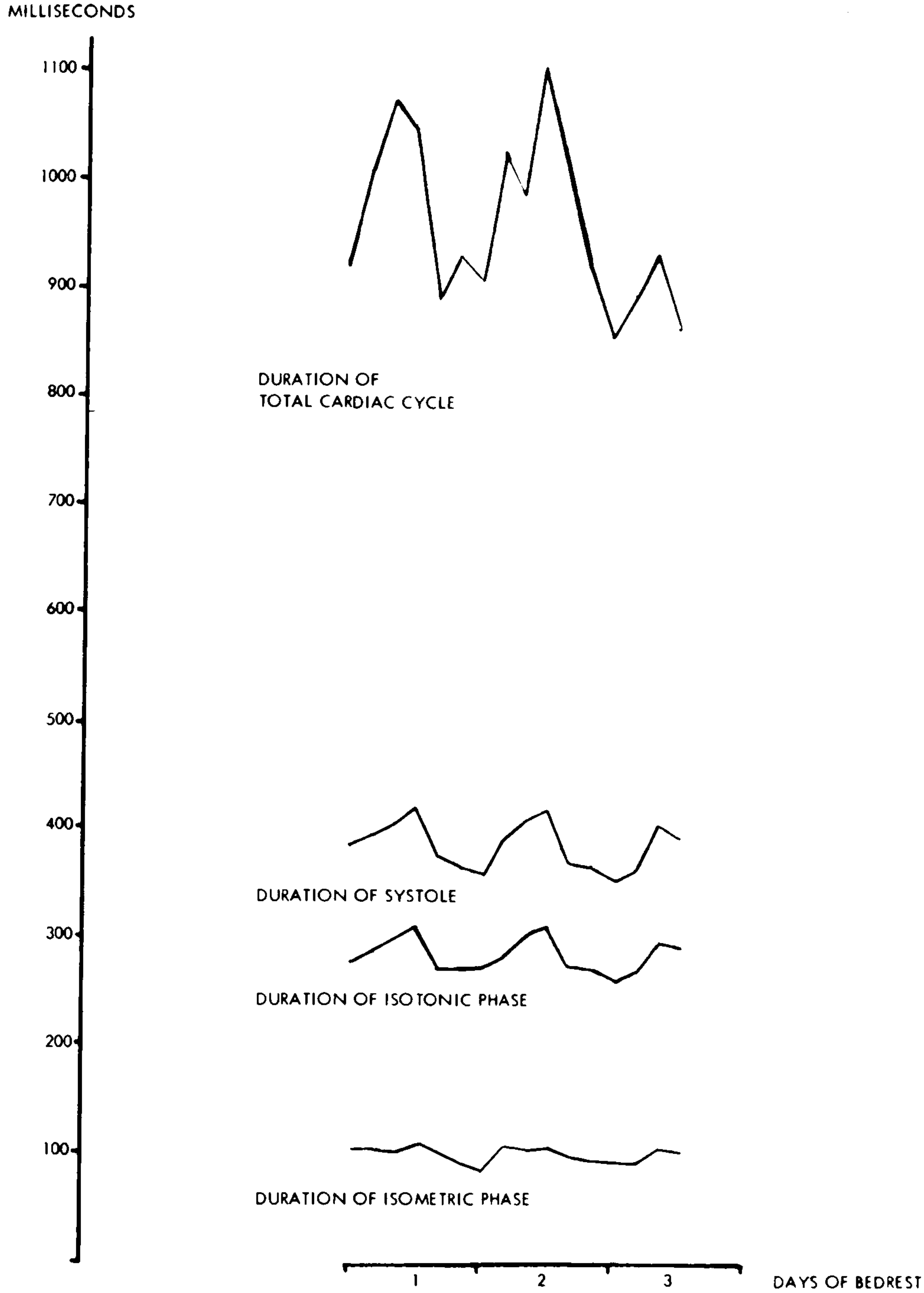

Figure 5

Average values of cardiac dynamics during three days of bedrest (Study I Period 1)

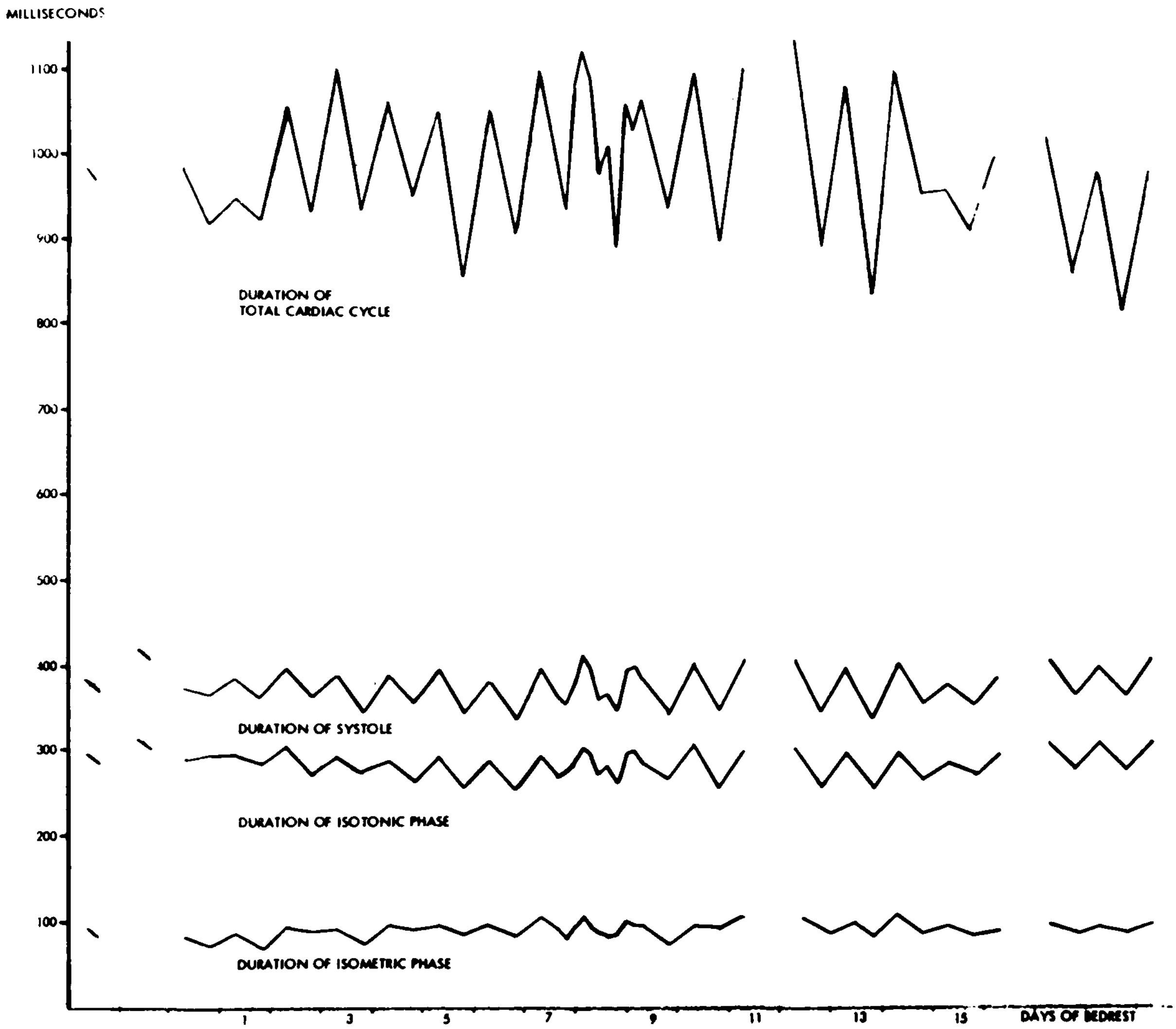

Figure 6

Average values of cardiac dynamics during fourteen days of bedrest (Study II Period 1) was a respiration-heart rate response. In the majority of the subjects the respiration-heart rate response was more prominent after midnight, even though the average heart rate remained the same.

The respiratory rate was stable in both periods, but it too showed circadian rhythm with higher values in the evening. The values in the second period of bedrest were slightly higher, but the differences were not significant, except for two occasions.

The measurements of blood pressure remained within normal limits in both periods. The systolic pressure showed a trend down in the first period with a marked decrease in differential pressure after the first 24 hours. This downward slope may represent a return to normal from the higher values at the beginning of bedrest rather than a drop from normal to lower values at the end. The diastolic blood pressure remained remarkably constant and essentially similar in both periods, although the values were slightly higher at the beginning of the first period.

The pulse wave velocity exhibited marked fluctuations in both periods. A circadian rhythm could not be demonstrated. The values of the pulse wave velocity were within normal limits in the first 36 hours of the first period, but a subtle rise in the values at the end of this period suggested a trend upward. The values in the first 36 hours of the second period were significantly higher ($p < 0.05$) than in the first. There was no apparent correlation between the pulse wave velocity and the systolic or diastolic blood pressures.

The duration of the systole and diastole fluctuated according to the changes in the heart rate (figure 5). When these rate changes were taken into consideration to determine the quotients of the observed and predicted systole, it became clear that the ratios remained within normal limits throughout the two periods. There was a clear circadian fluctuation of the values, with the lowest occurring in the evening hours (figure 3).

B. Results of the second study (14 days of bedrest)

The temperature fluctuated at about the same average level, with a clear-cut circadian rhythm. The evening temperatures were about one degree Fahrenheit higher than the morning.

The heart rate likewise failed to show any trend in the first period. It fluctuated about an average of 60 beats per minute and demonstrated a circadian rhythm, the lowest values being obtained in the morning.

The systolic blood pressure fluctuated along a stable value of about 120 millimeters of mercury. A circadian rhythm was also clearly established, the evening values being greater than in the morning. By the fifth day of bedrest, there seemed to be a trend down in the systolic blood pressure, but the trend reversed during the 48 hours of intensive monitoring (on the seventh and eighth days of bedrest). In the last two days of bedrest, the systolic pressure was significantly higher than at the beginning of bedrest. The diastolic blood pressure failed to reveal a clear-cut periodicity, although a circadian rhythm was suggested in the two days of intensive monitoring. The trend of the diastolic blood pressure also seemed to be down at the end of the fifth day of bedrest, but it was reversed at the time of intensive monitoring. It dropped to control values on the eleventh day, to rise again in parallel to the increase in the systolic values until the day when the subjects were taken off of bedrest.

The respiratory frequency remained stable throughout the period of monitoring, and the values fluctuated around an average of 19 breaths per minute. A circadian variation in the respiratory frequency was detected on all the days when monitoring was done in the morning and in the evening.

The vital signs were measured less often in the second period of this phase, but on the days when morning and evening values were obtained they also showed a circadian variation. It is interesting that a trend upward of the heart rate was manifest in the second period. In parallel, the systolic and diastolic blood pressure followed a trend upward which seemed to be consistent throughout this period of study. The respiratory rate remained stable around a value of 19 breaths per minute with a clear-cut circadian rhythm on the days that monitoring was done twice a day.

The average values of the observed-predicted systolic ratios and of the observed-predicted isotonic ratios obtained throughout the first period of the second study clearly show a circadian rhythm, with the lowest values of the ratios occurring during the monitoring session of the evening. A statistical test carried out to compare the difference between the morning and evening values showed that the difference was highly significant ($p < 0.01$). On the days when the monitoring was intensive (every four hours), the circadian rhythm could be clearly delineated. It is interesting also that the values of these ratios were consistently lower than 1.0 throughout the period of bedrest. The ratio became higher than 1.0 after the confinement in bed. These findings are in perfect agreement with observations that were made in the first phase of the study(when the bedrest was conducted over a period of 3 days).

The values of the pulse wave velocity fluctuated in a manner similar to the first phase. There was an unquestionable trend upward of the pulse wave velocity in the course of the first period. The values were on the lower side of normal before putting the individuals in bed, but as bedrest progressed the pulse wave velocity became significantly faster ($p < 0.05$). After bedrest, there was again a drop of the pulse wave velocity to values comparable to prebedrest. The pulse wave velocity exhibited also a circadian rhythm with higher values in the evening, but the differences were not as consistent or statistically significant as the changes in the phases of the cardiac cycle.

DISCUSSION

Differences in the experimental conditions between the first and the second studies warrant a separate discussion of the results.

A. The effect of three days of bedrest

Analysis of the vital signs in the two short periods of bedrest (one without exercise and one with exercise) failed to indicate any obvious signs of "cardiovascular deconditioning." It is possible that the short duration of this study failed to bring into evidence the gradual increase in the cardiac frequency that had been observed in previous studies,[1,2] and that was suggested also in the results of the study of fourteen days of bedrest.

The circadian fluctuations that were observed in the heart rate and in the systolic and isotonic ratios reflect possible differences in the vagal and sympathetic tone in the course of 24 hours. As has been indicated previously, the majority of the subjects had a more prominent respiration-heart rate response after midnight. This reflected a possible increase in the vagal tone of these individuals during the night and correlates with the nocturnal prolongation of the time of the mechanical systole including both its isotonic and isometric phases.

The meaning of the higher readings of the systolic and diastolic blood pressures immediately after starting the first period of bedrest is not clear. Since the pressure readings coincided with higher values of heart rate, an adrenergic reaction of excitement could be incriminated; but if such occurred, it did not cause a concomitant shortening of the systole.

The trend upward of the pulse wave velocity in the first period and the higher values in the second period may reflect an increased peripheral resistance resulting from an adrenergic response; but if this was the mechanism, it failed to cause a substantial rise in the diastolic blood pressure. It is possible that the pulse wave velocity is a more sensitive indicator of an increase in peripheral resistance and occurs earlier than the rise in diastolic blood pressure. The possibility of an error in the measurements of the pulse wave velocity cannot be excluded. If it did occur, it was consistently the same, since the standard deviation of the values of this study is even smaller than that of a previous investigation in healthy subjects in this laboratory.[12]

The values of the observed-predicted ratio of systole were significantly shorter in the second period. A circadian rhythm could be identified in this period also. A shortening of the duration of the mechanical systole, accompanied by a proportional shortening of both the isotonic and isometric phases, occurs as the cardiac frequency increases. However, a shortening in excess of that predicted for the increase in rate occurs under the influence of adrenergic agents[5,6,11] or digitalis.[14] In addition to a positive inotropic effect, it is likely that these agents speed up the metabolic reactions of the myocardium during systole. Cholinergic agents produce the opposite effect which results in an increase in the ratio between observed and predicted systole. The fact that the ratios were lower in the second period suggests that the subjects may have been under a greater influence of adrenergic factors than in the first period. Since the arterial blood pressure was not affected, it is tempting to speculate that the systole quotient may be a more sensitive indicator of stress than the other circulatory dynamics evaluated in this study. The finding and the interpretation are in agreement with the observed increase in the pulse wave velocity in the second period.

Subject W. S. (TIRR #70008) consistently showed lower values of the duration of systole and of the isotonic phase than predicted for the respective heart rate. This effect was more pronounced in the second period. It is interesting to note that this subject exhibited orthostatic hypotension even before the first bedrest period. Paradoxically, this subject had bradycardia persistently and the lowest blood pressure values of the group of subjects. In addition, he had a prominent respiration-heart rate response. Since these are manifestations of an increased vagal tone, a prolonged systole would be expected; but it is conceivable that in response to his vagal tone, there was a compensatory release of catecholamines. It is also conceivable that the level of catecholamines was ineffectual at the arteriolar level, but effective in producing a positive inotropic effect in the myocardium and a subsequent shortening of the systole. A teleological interpretation could be that the shorter systole allowed for greater time for ventricular filling to compensate for the diminished venous return secondary to a low peripheral resistance or to a low circulating blood volume. The difficulty of obtaining reliable measurements of blood volume in the first phase precludes the confirmation of this point. The measurement of cardiac dynamics in this subject during tilts revealed that the decrease in the systolic ratio could not be maintained in the upright posture, and perhaps this was one of the factors that led to the subjective and objective manifestations of impending syncope.

B. The effect of 14 days of bedrest

The serial evaluation of the vital signs suggested a slight trend upward of the heart rate which was more manifest in the second period of this study. An establishment of the statistical significance of this trend is contingent upon a pending regression analysis of the data. If the impression is confirmed it will be in agreement with the findings of others.[1,2]

The changes observed in the duration of the cardiac cycle and its phases suggest that the experiments of this study produced a situation of adrenergic preponderance, which was very evident on the days of intensive monitoring and which reversed immediately after cessation of confinement to bed. The urinary excretion of metabolites of catecholamines was increased throughout the two periods of the second study of fourteen days of bedrest. The highest rates of excretion occurred in the daytime hours, thus suggesting a higher adrenergic activity than at night. This probably accounts for the shorter duration of the phases of the cardiac cycle and for the lower values of the systolic and isotonic ratios in the evening sessions of monitoring. The "rebound" after bedrest may represent a cholinergic type of reaction which was clearly evident in the prolongation of the systolic and isotonic ratios, while it did not affect the pulse rate or the blood pressure values. The shortening of the duration of systole and its phases in the course of bedrest is an effect opposite to the prolongation brought about by a long term program of physical training[5] or by the administration of antiadrenergic drugs such as Rauwolfia derivatives.[17,18]

Since monitoring was done less frequently in the second period of bedrest (with isometric exercises), it is impossible to establish a day-by-day test of significance between the differences of the average values obtained in the two periods. Nevertheless, when monitoring was done at corresponding times, the lower values of the second period were statistically significant both for the systolic and isotonic ratios ($p < 0.05$). This suggested that in the second period there was an even greater adrenergic response than in the first. These results are also in perfect agreement with the observations of the first study when the systolic and isotonic ratios were lower during the days of bedrest with isometric exercise. These observations suggest that isometric exercises introduce a constellation of circumstances which contribute to the degree of adrenergic response.

The increase in the pulse wave velocity is not surprising if there was an adrenergic response throughout the period of bedrest. The peak reached during the days of intensive monitoring may indicate an even stronger reaction at this time. Presumably an adrenergic response should increase the peripheral resistance and cause higher velocities of the propagation of the pulse wave through the arterial tree. The values of the pulse wave velocity before the second period of bedrest were comparable to those before the first period, but the rise immediately after confinement to bed was more marked and significantly higher in the second period ($p < 0.05$) when a program of isometric exercises was carried out. These findings are also in agreement with lower systolic and isotonic ratios observed in this second period.

CONCLUSION

The results of this study, which was aimed at determining the variability of the vital signs and circulatory dynamics during bedrest, showed that there were no obvious signs of circulatory "deconditioning" when bedrest lasted for 72 hours. There were circadian fluctuations in the duration of the various phases of the cardiac cycle, and it was concluded that under the conditions of this study, the subjects were slightly under sympathetic stimulation. This was more manifest in the second period of the study when a program of isometric exercises was introduced as an added variable.

When bedrest was prolonged for a total of 14 days, the observations were in agreement with those of the first study, although there was a trend for the blood pressure to increase throughout the period of confinement. Circadian rhythms in the cardiac dynamics were also detected. The values of the systolic and isotonic ratios and of the pulse wave velocity suggest a slight degree of stress under the conditions of the experiment. The introduction of a program of isometric exercises during confinement to bed produced also changes in cardiac dynamics which are strongly suggestive of a greater reaction of sympathetic stimulation.

REFERENCES

1. Taylor, H. L., Henschel, A., Brozek, J., and Keys, A.: Effects of Bedrest on Cardiovascular Function and Work Performance. J. Appl. Physiol. 2: 223, 1949.

2. Deitrick, J. E., Whedon, G. D., and Shorr, E.: The Effects of Immobilization on Various Metabolic and Physiologic Functions of Normal Men. Amer. J. Med. 4: 3, 1948.

3. Graveline, D. E., Balke, B., McKenzie, R. E., and Hartman, B.: Psychobiological Effects of Water-Immersion-Induced Hypodynamics. Aerospace Med. 32: 387, 1961.

4. Graveline, D. E. and Barnard, G. W.: Physiologic Effects of a Hypodynamic Environment: Short-Term Studies. Aerospace Med. 32: 726, 1961.

5. Raab, W., Silva, P. de P. e, Marchet, H., Kimura, E., and Starcheska, Y. K.: Cardiac Adrenergic Preponderance Due to Lack of Physical Exercise and Its Pathogenic Implications. Amer. J. Cardiol. 5: 300, 1960.

6. Delius, L., Berg, W., and Waibel, V.: Untersuchungen zur Regulation der Systolendauer. Deutsches Archiv für Klinische Medizin 199: 554, 1952.

7. Schultz, H.: Ueber die Bestimmungsmöglichkeit der Anspannungszeit des Herzens. Zeitschrift für Kreislaufforschung. 29: 425, 1937.

8. Blumberger, Kj. : Die Untersuchung der Dynamik des Herzens beim Menschen. Ihre Awendung als Herzleistungsprufung. Ergebn. d. inn. Med. u. Kinderh., 62: 724, 1942.

9. Stollreiter, H.: Die physikalische Schlagoolumenbestimmung und ihre Brauchbarkeit als klinishche Herz-und Kreislauffunktions prüfung, Arch. f. Kreislaufforschg., 16: 174, 1949.

10. Kühns, K.: Ueber die Beziehung der "mechanischen Systole" (Q-2 Herzton) und der "elektrischen Systole" (Q-T) zur Herzfrequenz, Klin. Wschr. 30: 695, 1952.

11. Raab, W., Silva, P. de P. e, and Starcheska, Y. K.: Adrenergic and Cholinergic Influences on the Dynamic Cycle of the Normal Human Heart. Cardiologia, 33: 350, 1958.

12. Woolam, G. L., Schnur, P. L., Vallbona, C., and Hoff, H. E.: The Pulse Wave Velocity as an Early Indicator of Atherosclerosis in Diabetic Subjects. Circulation. 25: 533, 1962.

13. Hegglin, R. and Holzmann, M.: Die klinische Bedentung der Verlängerten QT-Distanz im Elektrokardiogramm. Ztschr. f. klin. Med. 132: 1, 1937.

14. Hegglin, R.: Die Klinik der energetischdynamischen Herzinsuffizienz. Bibliotheca Cardiologica, Sup. Cardiologia, Basel, 1947.

15. Blumberger, Kj.: Die Anspannungszeit und Austreibungszeit beim Menschen. Ztschr. f. Kreislaufforschg. 6: 203, 1940.

16. Blumberger, Kj. and Meiners, S.: Cardiology, Sponsored by American College of Cardiology. Edited by Aldo A. Luisada, M. D., McGraw-Hill Book Company, Inc., New York. Vol. 2: 14, 4-372, 1959.

17. Schumann, H.: Die Bedeutung der Diastolendauer für Hämodynamik und Therapie der Mitralklappenfehler. Ztschr. f. Kreislaufforschg. 45: 115, 1956.

18. Raab, W., Marchet, H., and Herrlich, H. C.: Effect of Reserpine and Syrosingopine on the Rate and Contractility of the Human Heart. Amer. J. Cardiol. 7: 404, 1961.

APPENDIX

TABLE A1

AVERAGE VALUES OF VITAL SIGNS

STUDY I - PERIOD 1

DATE	TIME	B.P.-SYS. N	B.P.-SYS. MEAN	B.P.-SYS. S.D.	B.P.-DIAS. N	B.P.-DIAS. MEAN	B.P.-DIAS. S.D.	HEART RATE N	HEART RATE MEAN	HEART RATE S.D.	RESP. N	RESP. MEAN	RESP. S.D.	TEMP N	TEMP MEAN	TEMP S.D.
5/ 6/63	1900	6	124.16	12.62	6	64.45	9.67	6	90.83	8.40	6	16.66	3.77	0	.00	.00
5/ 6/63	2300	6	124.54	9.42	6	70.54	12.37	6	84.41	13.91	6	16.83	2.78	0	.00	.00
5/ 7/63	300	6	116.58	16.31	6	68.79	8.14	6	53.00	5.65	6	15.50	2.81	0	.00	.00
5/ 7/63	700	6	115.29	9.82	6	65.75	8.25	6	60.41	13.41	6	14.83	2.04	0	.00	.00
5/ 7/63	1100	6	117.50	8.57	6	59.66	5.61	6	68.62	6.51	6	16.16	4.21	0	.00	.00
5/ 7/63	1500	6	117.45	9.18	6	58.83	6.16	6	62.82	8.78	6	17.50	3.01	0	.00	.00
5/ 7/63	1900	6	125.95	7.09	6	62.79	6.13	6	64.08	11.28	6	18.66	3.07	0	.00	.00
5/ 7/63	2300	6	118.91	10.61	6	63.87	4.87	6	66.08	5.56	6	15.16	2.78	0	.00	.00
5/ 8/63	300	6	116.12	9.08	6	64.41	8.97	6	65.58	9.80	6	14.83	2.48	0	.00	.00
5/ 8/63	700	6	118.20	7.89	6	61.75	3.05	6	62.79	7.59	6	14.66	2.06	0	.00	.00
5/ 8/63	1100	6	112.41	23.46	6	54.45	9.86	6	65.25	7.23	6	15.50	3.39	0	.00	.00
5/ 8/63	1500	6	107.70	13.11	6	63.08	6.93	6	64.08	7.87	6	15.83	3.25	0	.00	.00
5/ 8/63	1900	6	105.20	13.71	6	63.41	12.31	6	77.54	7.85	6	17.33	3.07	0	.00	.00
5/ 8/63	2300	6	110.33	16.40	6	69.87	7.70	6	67.95	4.96	6	15.16	3.12	0	.00	.00
5/ 9/63	300	6	102.00	16.36	6	64.12	15.39	6	60.41	5.60	6	16.16	2.48	0	.00	.00
5/ 9/63	700	6	103.37	13.79	6	64.29	8.92	6	64.45	7.98	6	15.66	2.06	0	.00	.00

TABLE A1 (continued)

AVERAGE VALUES OF VITAL SIGNS

STUDY I - PERIOD 2

DATE	TIME	B.P.-SYS. N	B.P.-SYS. MEAN	B.P.-SYS. S.D.	B.P.-DIAS. N	B.P.-DIAS. MEAN	B.P.-DIAS. S.D.	HEART RATE N	HEART RATE MEAN	HEART RATE S.D.	RESP. N	RESP. MEAN	RESP. S.D.	TEMP N	TEMP MEAN	TEMP S.D.
5/20/63	1900	5	102.60	13.05	5	57.40	6.09	6	72.16	8.39	6	19.50	3.20	5	98.24	.16
5/20/63	2300	6	103.04	6.09	6	58.95	10.15	6	65.29	5.88	6	17.16	2.31	6	98.10	.41
5/21/63	300	6	97.75	7.57	6	59.54	5.64	6	63.45	8.35	6	17.00	1.78	6	97.03	.38
5/21/63	700	6	99.20	5.01	6	58.08	5.62	6	60.33	7.43	6	16.66	1.86	5	97.04	.40
5/21/63	1100	6	112.33	9.23	6	65.91	7.90	6	63.25	9.37	6	21.33	2.06	4	98.20	.40
5/21/63	1500	6	105.79	4.67	6	56.29	12.63	6	58.58	7.02	6	18.00	3.63	6	98.53	.43
5/21/63	1900	6	107.37	10.23	6	60.37	9.73	6	64.50	12.77	6	18.83	2.78	6	98.50	.20
5/21/63	2300	6	104.12	9.46	6	62.79	8.67	6	61.62	4.96	6	17.33	4.08	1	98.60	.00
5/22/63	300	6	99.37	6.09	6	60.45	7.76	6	57.54	5.72	6	15.33	1.50	6	97.40	.35
5/22/63	700	6	98.04	10.54	6	59.45	6.77	6	60.83	6.49	6	15.16	2.48	6	96.73	.45
5/22/63	1100	6	100.33	8.92	6	54.54	11.60	6	75.54	12.33	6	17.66	3.32	6	97.76	.44
5/22/63	1500	6	112.83	6.43	6	68.66	4.75	6	68.41	14.89	6	20.50	2.34	6	98.50	.20
5/22/63	1900	6	110.91	8.73	6	65.29	4.84	6	61.29	10.84	6	17.16	3.54	6	98.43	.19
5/22/63	2300	6	102.66	7.80	6	65.62	11.06	6	54.45	5.53	6	17.83	3.92	6	98.20	.33
5/23/63	300	6	98.58	5.85	6	63.95	6.76	6	53.91	5.10	6	15.66	2.06	0	.00	.00
5/23/63	700	6	112.12	4.13	6	66.87	5.40	6	59.00	8.23	6	14.00	3.89	6	97.26	.85

TABLE A1 (continued)

AVERAGE VALUES OF VITAL SIGNS

STUDY II - PERIOD 1

DATE	TIME	B.P.-SYS. N	B.P.-SYS. MEAN	B.P.-SYS. S.D.	B.P.-DIAS. N	B.P.-DIAS. MEAN	B.P.-DIAS. S.D.	HEART RATE N	HEART RATE MEAN	HEART RATE S.D.	RESP. N	RESP. MEAN	RESP. S.D.	TEMP N	TEMP MEAN	TEMP S.D.
7/19/63	1212	6	121.77	5.84	6	60.54	2.63	6	58.97	6.95	6	20.00	4.04	1	98.20	.00
7/20/63	1305	2	120.75	1.41	2	54.06	8.04	2	55.36	14.56	2	17.50	.70	0	.00	.00
7/21/63	850	6	123.95	8.52	6	55.51	4.33	6	62.08	9.69	6	18.66	2.06	6	97.58	.58
7/22/63	720	6	119.51	7.06	6	66.62	5.24	6	59.79	4.54	5	18.00	.70	5	96.96	.71
7/22/63	1920	6	129.04	9.46	6	64.19	6.77	6	61.70	8.31	6	20.00	2.75	0	.00	.00
7/23/63	720	6	110.38	8.30	6	57.72	7.04	6	55.29	3.81	5	19.00	1.73	5	98.30	.40
7/23/63	1910	6	136.05	12.12	6	62.96	4.86	6	56.35	6.30	6	19.16	.75	6	98.38	.27
7/24/63	715	6	131.25	3.36	0	.00	.00	6	53.63	5.56	6	18.16	1.16	6	97.71	.34
7/24/63	1919	6	128.18	9.69	6	62.47	7.50	6	58.63	4.45	5	19.00	2.12	6	98.45	.28
7/25/63	725	6	120.97	8.49	6	69.12	9.87	6	53.87	5.65	6	18.00	.63	6	97.55	.32
7/25/63	2030	6	127.77	13.72	6	66.74	5.85	6	66.07	9.76	6	21.50	3.14	6	98.65	.61
7/26/63	725	6	116.18	6.14	6	67.70	3.69	6	55.54	7.23	6	17.83	2.31	6	97.33	.50
7/26/63	1859	6	127.91	12.69	6	63.83	10.10	6	67.90	8.15	6	20.50	3.01	6	98.70	.23
7/27/63	740	6	111.18	6.14	6	53.88	4.86	6	55.84	7.85	6	17.00	2.28	6	98.35	.23
7/27/63	1907	6	121.33	3.53	6	51.01	7.63	6	64.05	10.72	5	19.40	4.21	5	98.34	.65
7/28/63	710	6	109.74	10.99	6	60.22	8.26	6	50.93	6.44	6	18.00	3.89	6	98.00	.67
7/28/63	1500	6	124.24	7.26	6	64.69	8.16	6	61.27	8.22	6	19.16	2.78	0	.00	.00
7/28/63	1920	6	147.56	13.99	6	75.83	6.22	6	63.13	10.09	6	18.66	1.50	0	.00	.00
7/28/63	2300	6	140.95	9.56	6	82.69	7.83	6	54.54	6.96	6	17.83	1.83	0	.00	.00
7/29/63	725	6	142.58	7.01	6	88.66	8.84	6	53.94	5.88	4	18.75	1.50	6	98.15	.23
7/29/63	1105	6	148.00	6.57	6	71.20	7.92	6	62.78	10.14	5	17.80	2.16	0	.00	.00
7/29/63	1512	6	133.16	21.02	6	66.22	6.69	6	61.40	8.61	6	20.00	1.89	0	.00	.00
7/29/63	1910	6	128.94	16.68	6	72.01	5.57	6	71.17	17.58	6	19.16	2.63	6	98.75	.33
7/29/63	2310	6	119.25	13.90	6	75.55	9.97	6	56.51	11.14	5	18.40	1.67	0	.00	.00
7/30/63	718	6	119.27	12.26	6	70.68	8.37	6	59.67	16.58	6	18.00	1.67	5	97.92	.17
7/30/63	1910	1	123.75	.00	2	79.83	52.08	6	68.85	11.27	6	19.16	2.63	6	98.40	.25
7/31/63	710	0	.00	.00	0	.00	.00	6	56.06	5.65	6	18.00	2.60	6	97.41	.24
7/31/63	1927	5	123.85	8.03	5	76.45	6.45	6	66.43	10.07	6	19.66	2.33	6	98.76	.36

TABLE A1 (continued)

AVERAGE VALUES OF VITAL SIGNS

STUDY II - PERIOD 1

DATE	TIME	B.P.-SYS. N	B.P.-SYS. MEAN	B.P.-SYS. S.D.	B.P.-DIAS. N	B.P.-DIAS. MEAN	B.P.-DIAS. S.D.	HEART RATE N	HEART RATE MEAN	HEART RATE S.D.	RESP. N	RESP. MEAN	RESP. S.D.	TEMP N	TEMP MEAN	TEMP S.D.
8/ 1/63	715	6	115.29	3.84	6	73.54	5.84	6	52.07	5.13	6	19.66	2.87	6	97.38	.36
8/ 2/63	1900	6	126.02	2.82	6	63.92	4.45	6	61.49	8.17	6	18.66	2.06	6	98.81	.17
8/ 3/63	720	6	119.47	11.04	6	70.24	10.33	6	57.80	5.98	6	16.16	1.94	6	97.60	.33
8/ 3/63	1905	4	142.90	4.05	4	75.62	8.72	4	69.21	8.48	4	20.50	2.38	4	97.42	2.01
8/ 4/63	704	6	129.47	6.66	6	77.70	8.34	6	53.16	5.51	6	17.16	1.16	6	97.46	.30
8/ 4/63	1920	6	138.22	8.66	6	74.45	6.78	6	63.28	10.49	6	17.33	2.50	6	98.51	.28
8/ 5/63	713	6	135.85	5.88	6	80.47	9.34	6	65.51	13.88	6	19.00	2.09	5	97.40	.69
8/ 5/63	1925	6	121.97	7.77	6	56.29	8.55	6	70.60	9.99	6	19.33	2.65	6	98.50	.35
8/ 6/63	1912	6	118.37	6.59	6	51.10	6.00	6	62.13	7.79	6	18.00	1.67	6	98.46	.46
8/ 7/63	715	6	125.60	7.04	6	63.64	9.65	6	59.66	6.11	0	.00	.00	0	.00	.00
8/ 7/63	1908	6	136.16	4.95	6	67.54	6.33	6	68.25	13.27	6	21.00	3.09	6	98.63	.65
8/ 8/63	725	6	126.93	6.09	6	68.24	7.59	6	63.89	9.78	6	18.83	1.94	6	97.45	.20
8/ 8/63	1900	6	135.76	10.74	6	70.38	5.24	6	73.81	16.62	6	20.66	1.75	6	98.45	.19
8/ 9/63	715	6	128.18	7.39	6	75.70	9.37	6	58.70	7.04	5	18.80	1.92	5	97.92	.76

TABLE A1 (concluded)

AVERAGE VALUES OF VITAL SIGNS

STUDY II - PERIOD 2

DATE	TIME	B.P.-SYS. N	B.P.-SYS. MEAN	B.P.-SYS. S.D.	B.P.-DIAS. N	B.P.-DIAS. MEAN	B.P.-DIAS. S.D.	HEART RATE N	HEART RATE MEAN	HEART RATE S.D.	RESP. N	RESP. MEAN	RESP. S.D.	TEMP N	TEMP MEAN	TEMP S.D.
8/15/63	1850	6	116.58	8.76	6	71.47	2.78	6	65.89	12.19	6	20.66	2.65	6	98.06	.35
8/17/63	715	6	118.26	7.12	6	65.29	5.76	6	54.23	5.14	6	19.00	2.60	4	97.75	.57
8/17/63	1850	6	108.53	4.31	6	47.80	4.63	6	72.82	13.38	6	20.33	3.01	3	97.53	.30
8/20/63	922	4	126.12	7.98	4	65.18	5.67	6	58.65	6.64	6	20.66	2.16	6	97.51	.27
8/20/63	1855	6	127.22	3.89	6	60.58	8.23	6	53.50	7.84	6	20.66	2.58	6	98.38	.46
8/22/63	720	6	114.30	6.30	6	52.58	5.13	6	52.82	2.92	6	18.50	1.64	6	97.58	.25
8/22/63	1850	6	121.41	7.23	6	53.56	4.45	6	58.69	7.97	6	19.16	1.32	6	98.38	.42
8/26/63	855	6	123.45	3.52	6	66.28	5.96	6	62.87	7.12	6	19.33	3.07	6	97.60	.23
8/27/63	720	6	110.91	10.67	6	65.85	6.33	6	54.44	5.16	6	18.00	2.89	6	97.36	.27
8/27/63	1855	6	125.43	5.51	6	60.81	6.25	6	65.83	11.13	6	18.33	2.50	6	98.73	.28
8/28/63	730	6	114.99	3.69	6	61.81	5.00	6	49.13	3.54	6	18.16	3.92	6	97.58	.24
8/28/63	1905	6	130.55	5.86	6	57.79	5.37	6	62.68	10.52	3	18.33	.57	3	98.83	.35
8/29/63	710	6	109.06	8.36	6	64.57	5.66	6	52.38	5.81	6	17.33	1.63	6	97.28	.29
8/29/63	1845	6	130.12	5.98	6	60.66	4.37	6	66.64	11.80	6	21.16	2.63	6	98.78	.27
8/30/63	732	6	119.39	9.13	6	62.10	5.94	6	55.28	3.39	6	17.16	1.94	2	98.30	.14
8/30/63	1855	6	122.17	8.97	6	59.45	8.90	6	64.02	12.33	6	19.83	1.94	5	98.66	.08
8/31/63	915	6	129.06	4.95	6	65.22	7.72	6	69.96	14.48	6	19.00	1.09	4	97.27	.30
8/31/63	1905	6	129.38	6.48	6	48.64	4.46	6	65.76	13.24	6	19.16	1.47	6	98.68	.65
9/ 1/63	906	5	125.44	5.09	5	60.77	2.49	5	71.14	12.47	5	18.00	2.00	5	97.92	.10
9/ 1/63	1901	5	134.82	6.19	5	66.85	3.44	5	66.28	12.83	5	18.00	1.22	5	98.34	.41
9/ 2/63	657	5	125.69	6.74	5	73.37	11.07	5	56.65	6.61	5	15.80	1.48	5	97.26	.29
9/ 3/63	725	4	113.71	4.21	4	62.31	6.08	4	57.83	5.97	4	18.25	3.50	4	97.07	.33
9/ 4/63	715	3	117.16	7.93	3	67.29	11.57	3	59.91	4.66	0	.00	.00	0	.00	.00
9/ 5/63	730	4	110.68	3.32	4	65.78	4.34	4	57.05	5.53	0	.00	.00	0	.00	.00

TABLE A2

AVERAGE VALUES OF CARDIAC DYNAMICS[a]

STUDY I - PERIOD 1

DATE	TIME	TOTAL CYCLE N	TOTAL CYCLE MEAN	TOTAL CYCLE S.D.	SYSTOLE N	SYSTOLE MEAN	SYSTOLE S.D.	DIASTOLE N	DIASTOLE MEAN	DIASTOLE S.D.	ISOTONIC N	ISOTONIC MEAN	ISOTONIC S.D.	PULSE WAVE VEL. N	PULSE WAVE VEL. MEAN	PULSE WAVE VEL. S.D.
5/ 6/63	1900	6	920.56	93.16	6	387.00	25.42	6	533.56	84.39	6	279.75	20.35	6	7.70	1.55
5/ 6/63	2300	6	1007.09	181.24	6	396.16	31.35	6	610.92	151.44	6	289.64	33.58	6	7.18	.67
5/ 7/63	300	6	1072.80	169.14	6	403.50	27.66	6	669.30	146.43	6	299.43	30.14	5	8.07	.64
5/ 7/63	700	6	1044.52	173.13	6	420.00	26.07	6	624.52	152.26	6	310.42	21.87	6	7.49	1.34
5/ 7/63	1100	6	890.23	81.63	6	375.66	28.99	6	514.56	58.81	6	273.04	26.84	6	7.60	1.45
5/ 7/63	1500	6	929.51	135.09	6	364.31	21.43	6	565.20	116.08	6	272.24	27.44	6	7.72	.77
5/ 7/63	1900	6	903.92	144.91	5	360.06	25.20	5	528.93	131.87	5	274.90	22.40	6	8.06	1.27
5/ 7/63	2300	6	1025.26	116.66	6	390.82	15.69	6	634.43	103.82	6	282.27	16.44	5	9.08	1.58
5/ 8/63	300	6	988.63	127.90	6	407.18	17.12	6	581.44	118.41	6	300.51	22.23	6	7.87	1.86
5/ 8/63	700	6	1102.35	158.40	6	418.11	22.68	6	684.24	138.81	6	310.45	24.57	5	7.55	1.21
5/ 8/63	1100	6	915.89	101.15	5	371.56	17.22	5	563.13	83.79	6	272.80	25.11	6	8.52	.90
5/ 8/63	1500	6	925.87	112.81	6	367.36	22.63	6	558.51	93.23	6	271.54	24.00	6	22.94	36.09
5/ 8/63	1900	6	855.40	80.11	6	353.57	10.83	6	501.83	71.92	6	260.45	16.98	6	8.78	.79
5/ 8/63	2300	6	892.16	92.53	6	362.81	16.00	6	529.35	83.64	6	269.01	16.93	6	8.87	1.05
5/ 9/63	300	6	1030.84	182.32	6	403.62	23.50	6	627.21	161.46	5	297.18	28.70	5	7.47	.78
5/ 9/63	700	6	962.77	148.56	6	393.81	20.19	6	568.95	129.92	5	291.04	20.00	5	9.34	2.70

[a] All values are given in milliseconds except pulse wave velocity values are expressed in meters per second.

TABLE A2 (continued)

AVERAGE VALUES OF CARDIAC DYNAMICS[a]

STUDY I - PERIOD 2

DATE	TIME	TOTAL CYCLE N	TOTAL CYCLE MEAN	TOTAL CYCLE S.D.	SYSTOLE N	SYSTOLE MEAN	SYSTOLE S.D.	DIASTOLE N	DIASTOLE MEAN	DIASTOLE S.D.	ISOTONIC N	ISOTONIC MEAN	ISOTONIC S.D.	PULSE WAVE VEL. N	PULSE WAVE VEL. MEAN	PULSE WAVE VEL. S.D.
5/20/63	1900	6	948.76	114.12	6	365.46	22.85	6	583.29	94.27	5	273.85	20.10	6	8.32	.76
5/20/63	2300	6	1063.33	128.10	6	389.19	21.03	6	674.13	114.32	5	292.30	22.06	5	8.60	2.41
5/21/63	300	6	1077.40	148.73	6	410.17	21.61	6	667.22	133.56	6	309.25	20.27	6	7.84	1.24
5/21/63	700	6	1112.87	158.16	6	408.07	24.73	6	704.79	135.30	6	305.66	28.71	6	9.01	1.17
5/21/63	1100	6	903.13	85.81	6	367.16	7.85	6	535.97	78.43	6	275.44	9.97	5	9.79	1.80
5/21/63	1500	6	995.06	106.28	6	371.11	22.71	6	623.95	84.97	6	289.60	22.41	6	7.90	1.21
5/21/63	1900	6	947.67	162.22	6	362.42	24.86	6	585.24	138.06	3	283.73	26.06	5	9.36	1.54
5/21/63	2300	6	1050.81	148.61	5	384.07	28.22	5	683.69	134.43	5	286.23	29.29	5	9.53	1.67
5/22/63	300	6	1125.68	159.92	6	412.38	19.28	6	713.30	145.17	6	300.35	20.81	6	9.18	2.11
5/22/63	700	6	1041.03	167.57	6	402.51	30.53	6	638.51	139.27	5	286.71	26.66	5	9.45	1.33
5/22/63	1100	6	876.81	163.77	6	361.47	31.75	6	515.33	132.76	6	269.11	28.08	6	8.30	1.18
5/22/63	1500	6	864.25	161.13	6	343.50	35.10	6	520.75	130.86	6	256.94	29.75	5	8.49	.98
5/22/63	1900	6	905.78	129.73	6	355.31	23.40	6	550.47	109.11	6	264.65	23.84	5	8.14	.80
5/22/63	2300	6	995.40	138.38	6	384.00	16.97	6	611.39	123.80	6	279.71	25.57	6	8.40	4.40
5/23/63	300	6	1111.82	161.91	6	407.71	14.69	6	704.10	147.48	6	305.59	31.69	6	7.66	1.47
5/23/63	700	6	987.44	171.70	6	393.55	28.31	6	593.88	146.39	6	289.19	29.68	6	8.24	1.12

[a] All values are given in milliseconds except pulse wave velocity values are expressed in meters per second.

28

TABLE A2 (continued)

AVERAGE VALUES CF CARDIAC DYNAMICS[a]

STUDY II - PERIOD 1

DATE	TIME	N	TOTAL CYCLE MEAN	TOTAL CYCLE S.D.	N	SYSTOLE MEAN	SYSTOLE S.D.	N	DIASTOLE MEAN	DIASTOLE S.D.	N	ISOTONIC MEAN	ISOTONIC S.D.	N	PULSE WAVE VEL. MEAN	PULSE WAVE VEL. S.D.
7/19/63	1212	6	977.6C	118.30	6	379.10	15.16	6	598.49	105.43	6	292.47	16.29	5	6.70	1.80
7/20/63	1305	2	1132.55	277.65	2	416.00	23.00	2	716.55	254.65	2	311.88	17.99	2	6.53	.58
7/21/63	85C	6	984.33	195.63	6	372.31	19.43	6	612.02	177.89	5	290.80	8.40	6	8.14	1.82
7/21/63	2127	1	920.11	.00	1	368.80	.00	1	551.31	.00	1	293.64	.00	1	9.29	.00
7/22/63	72C	6	947.41	74.81	6	384.95	8.05	6	562.45	71.52	5	295.10	17.49	6	7.96	1.79
7/22/63	192C	6	922.72	98.87	6	363.79	12.63	6	558.93	88.33	6	283.37	13.41	6	7.68	.95
7/23/63	730	6	1052.69	97.05	6	397.72	12.82	6	654.97	96.26	6	302.74	12.94	6	7.86	1.10
7/23/63	191C	6	933.86	38.51	6	362.92	16.15	6	570.94	39.62	6	272.76	6.79	6	7.20	1.49
7/24/63	715	6	1099.97	126.56	6	389.01	7.76	6	710.96	123.45	6	297.85	7.65	6	8.80	1.59
7/24/63	1919	6	936.55	78.46	6	349.51	5.37	6	587.04	76.17	6	273.99	16.86	6	9.41	2.70
7/25/63	725	6	1059.89	144.89	6	386.58	1C.12	6	673.30	139.51	6	288.94	8.16	6	6.76	1.25
7/25/63	203C	6	950.74	172.28	6	355.54	17.16	6	595.19	158.10	6	264.66	19.77	6	7.66	.84
7/26/63	725	6	1046.68	141.59	6	392.31	7.20	6	654.36	140.77	6	293.34	4.70	6	7.23	.83
7/26/63	19CC	6	857.07	143.23	6	347.85	13.54	6	509.22	131.26	6	258.61	20.72	6	7.45	.92
7/27/63	74C	6	1050.25	189.01	6	383.44	17.15	6	666.80	176.47	5	287.93	14.49	6	7.09	1.23
7/27/63	19C7	6	907.15	155.18	6	337.38	14.10	6	569.77	142.72	6	255.79	16.97	6	7.56	1.27
7/28/63	710	6	1C93.12	154.85	5	396.04	9.35	5	689.93	166.90	6	291.60	10.18	6	7.51	.90
7/28/63	15CC	6	991.7C	131.27	6	363.37	16.63	6	628.32	118.14	6	270.37	9.56	6	9.66	2.80
7/28/63	192C	6	938.64	174.27	6	357.35	21.22	6	581.28	155.07	6	274.06	14.72	6	7.80	1.47
7/28/63	23CC	6	1078.85	196.27	5	380.91	23.02	5	684.35	195.24	6	286.52	14.50	6	8.34	1.37
7/29/63	310	6	1122.47	119.91	6	410.7C	15.17	6	711.76	115.12	6	303.06	9.54	5	9.05	1.58
7/29/63	725	6	1087.66	116.17	6	391.42	9.39	6	696.24	114.79	6	298.57	7.97	6	8.20	1.88
7/29/63	11C5	6	976.33	140.1C	6	360.25	10.48	6	616.08	130.37	6	272.32	9.82	6	8.51	1.18
7/29/63	1512	6	1007.55	138.24	6	363.40	10.93	6	644.15	128.92	6	281.23	9.11	6	7.47	1.12

[a] All values are given in milliseconds except pulse wave velocity values are expressed in meters per second.

TABLE A2 (continued)

AVERAGE VALUES OF CARDIAC DYNAMICS[a]

STUDY II - PERIOD 1

DATE	TIME	N	TOTAL CYCLE MEAN	TOTAL CYCLE S.D.	N	SYSTOLE MEAN	SYSTOLE S.D.	N	DIASTOLE MEAN	DIASTOLE S.D.	N	ISOTONIC MEAN	ISOTONIC S.D.	N	PULSE WAVE VEL. MEAN	PULSE WAVE VEL. S.D.
7/29/63	1910	6	889.82	208.86	6	348.09	23.80	6	541.72	187.25	6	261.70	23.39	6	9.29	1.20
7/29/63	2310	6	1053.51	187.81	6	393.20	18.28	6	660.31	174.79	6	293.97	14.36	6	8.88	.66
7/30/63	320	5	1029.53	130.99	6	396.25	19.45	5	638.33	122.61	6	299.55	12.28	6	9.60	1.68
7/30/63	718	6	1062.55	194.58	6	384.45	20.68	6	678.09	179.14	6	286.39	11.49	6	9.27	1.88
7/30/63	1910	6	937.46	192.18	5	342.27	6.27	5	521.05	67.55	6	268.41	16.62	6	8.88	1.21
7/31/63	710	6	1095.85	109.67	6	400.41	10.70	6	695.43	110.88	6	303.45	5.85	6	8.99	1.27
7/31/63	1927	6	897.32	158.97	4	349.80	15.23	4	469.41	77.35	6	258.72	27.09	6	9.55	2.08
8/ 1/63	715	6	1096.13	150.46	6	403.43	19.50	6	692.69	142.28	6	298.72	11.69	6	8.36	.91
8/ 2/63	715	6	1132.12	129.50	6	402.03	16.42	6	730.09	130.25	6	300.05	3.68	6	8.67	1.18
8/ 2/63	1900	6	888.68	192.47	6	343.08	20.74	6	545.60	174.74	6	257.89	8.85	6	8.69	.90
8/ 3/63	720	6	1078.53	152.00	6	396.27	13.18	6	682.26	144.28	6	297.28	6.57	6	8.59	2.02
8/ 3/63	1905	6	839.92	202.48	5	338.70	22.51	5	503.88	204.02	6	255.09	20.47	6	7.69	1.25
8/ 4/63	704	6	1098.04	121.34	6	399.57	12.49	6	698.46	115.78	6	295.92	9.29	6	8.41	1.52
8/ 4/63	1920	6	954.43	183.46	6	354.48	13.23	6	599.95	171.63	6	267.59	13.52	5	8.89	1.46
8/ 5/63	713	6	957.22	220.48	6	377.29	28.82	6	579.93	195.57	6	284.88	13.21	6	8.15	1.18
8/ 5/63	1925	6	910.34	142.71	6	354.73	12.02	6	555.61	133.63	6	271.93	13.30	6	7.84	1.97
8/ 6/63	712	6	992.89	92.62	6	383.12	11.98	6	609.77	90.79	6	294.46	4.66	6	6.79	.90
8/ 7/63	715	6	1017.78	131.27	6	402.72	15.85	6	615.05	122.00	6	306.30	5.72	6	9.52	2.55
8/ 7/63	1908	6	857.88	226.77	6	362.05	19.00	6	495.83	209.46	6	276.13	20.43	5	7.49	2.45
8/ 8/63	725	6	975.58	145.28	6	398.63	14.89	6	576.95	138.48	6	307.88	11.37	6	7.11	1.83
8/ 8/63	1900	6	813.22	156.80	6	362.00	18.21	6	451.21	140.80	6	277.35	15.98	6	6.82	2.58
8/ 9/63	715	6	977.54	121.13	6	403.99	17.08	6	573.54	109.55	6	309.04	13.28	6	6.77	1.84

[a] All values are given in milliseconds except pulse wave velocity values are expressed in meters per second.

TABLE A2 (concluded)

AVERAGE VALUES OF CARDIAC DYNAMICS[a]

STUDY II – PERIOD 2

DATE	TIME	N	TOTAL CYCLE MEAN	TOTAL CYCLE S.D.	N	SYSTOLE MEAN	SYSTOLE S.D.	N	DIASTOLE MEAN	DIASTOLE S.D.	N	ISOTONIC MEAN	ISOTONIC S.D.	N	PULSE WAVE VEL. MEAN	PULSE WAVE VEL. S.D.
8/15/63	1850	6	908.37	161.71	6	365.72	9.88	6	542.65	160.47	6	285.89	9.16	6	7.38	1.96
8/17/63	715	6	1130.66	62.51	6	402.84	17.98	6	727.82	71.99	6	311.69	11.08	6	6.90	.76
8/17/63	1850	6	852.97	165.75	6	355.45	17.38	6	497.52	150.68	6	276.79	15.25	6	7.29	1.39
8/20/63	922	6	893.54	169.67	6	344.16	23.99	6	549.38	148.58	6	279.56	41.18	6	8.17	.94
8/20/63	1855	6	981.77	196.16	6	355.74	12.12	6	626.03	188.60	6	269.23	17.58	6	9.07	1.21
8/22/63	720	6	1119.72	79.80	6	392.06	17.13	6	727.66	79.78	6	301.38	8.69	6	8.89	1.68
8/22/63	1850	6	973.34	117.27	6	351.55	8.95	6	621.79	114.78	6	271.53	16.35	6	8.60	1.17
8/26/63	855	6	1004.39	79.17	6	354.60	13.60	6	649.78	77.04	6	272.39	11.47	6	8.17	.91
8/27/63	720	6	1091.38	151.19	6	386.88	20.35	6	704.50	148.11	6	295.02	10.91	6	6.52	3.25
8/27/63	1855	6	899.60	154.21	6	344.81	16.37	6	554.78	141.24	6	269.56	16.10	6	7.85	1.27
8/28/63	730	6	1110.08	52.38	6	393.62	17.33	6	716.46	57.94	6	300.35	6.17	6	9.27	2.64
8/28/63	1905	6	933.47	154.53	6	345.74	10.05	6	587.73	146.89	6	261.76	19.90	6	9.03	1.02
8/29/63	710	5	1112.12	124.05	5	392.11	20.85	5	720.00	118.61	5	291.10	6.34	5	9.18	1.20
8/29/63	1845	6	934.77	164.84	6	342.79	13.96	6	591.97	153.45	6	261.82	20.64	6	9.22	1.12
8/30/63	732	6	1045.89	143.84	6	383.78	21.56	6	662.11	132.83	6	285.65	8.30	6	7.47	1.15
8/30/63	1855	6	922.48	155.91	6	353.31	13.28	6	569.16	146.54	6	264.89	16.15	6	8.15	1.98
8/31/63	915	6	865.20	171.67	6	350.20	20.88	6	514.99	155.81	6	263.06	18.14	6	7.88	1.02
8/31/63	1905	6	855.19	157.38	6	340.83	14.82	6	514.35	146.39	6	255.56	21.33	6	8.14	2.03
9/ 1/63	920	5	846.66	141.30	5	344.51	16.48	5	502.14	131.14	5	260.20	19.29	5	8.49	.76
9/ 1/63	1901	5	899.05	159.12	5	346.89	18.01	5	552.16	148.13	5	259.31	15.66	5	8.95	.79
9/ 2/63	657	5	1025.68	113.07	5	387.06	21.44	5	638.61	108.23	5	287.17	11.73	5	8.76	2.01
9/ 3/63	725	4	980.26	124.19	4	383.37	18.21	4	596.88	114.62	4	292.94	4.41	4	9.57	2.22
9/ 4/63	715	4	1059.11	90.43	4	390.30	9.93	4	668.81	83.13	4	299.62	6.00	4	8.58	.73
9/ 5/63	730	4	991.49	82.15	4	388.69	14.22	4	602.80	79.37	4	301.26	.64	4	8.73	1.42

[a] All values are given in milliseconds except pulse wave velocity values are expressed in meters per second.

TABLE A3

AVERAGE VALUES OF OBSERVED/PREDICTED
RATIOS OF CARDIAC DYNAMICS

STUDY I - PERIOD 1

DATE	TIME	S/S* N	S/S* MEAN	S/S* S.D.	I/I* N	I/I* MEAN	I/I* S.D.	M/M* N	M/M* MEAN	M/M* S.D.	I/M N	I/M MEAN	I/M S.D.
5/ 6/63	1900	6	1.005	.047	6	.948	.049	6	1.202	.189	6	2.620	.300
5/ 6/63	2300	6	1.018	.027	6	.952	.054	6	1.266	.231	6	2.730	.450
5/ 7/63	300	6	1.018	.024	6	.963	.048	6	1.225	.245	6	2.980	.780
5/ 7/63	700	6	1.061	.047	6	1.010	.050	6	1.248	.170	6	2.840	.270
5/ 7/63	1100	6	1.020	.049	6	.936	.069	6	1.344	.274	6	2.760	.670
5/ 7/63	1500	6	.965	.027	6	.919	.047	6	1.146	.261	6	3.040	.790
5/ 7/63	1900	5	.983	.018	5	.945	.035	5	1.140	.164	5	3.240	.380
5/ 7/63	2300	6	.992	.030	6	.923	.033	6	1.236	.162	6	2.600	.280
5/ 8/63	300	6	1.053	.049	6	.995	.051	6	1.272	.226	6	2.830	.400
5/ 8/63	700	6	1.024	.037	6	.990	.037	6	1.151	.218	6	2.890	.370
5/ 8/63	1100	5	.986	.011	6	.926	.051	5	1.167	.209	6	2.360	1.690
5/ 8/63	1500	6	.980	.028	6	.919	.049	6	1.218	.177	6	2.840	.370
5/ 8/63	1900	6	.982	.032	6	.906	.032	6	1.296	.300	6	2.840	.510
5/ 8/63	2300	6	.986	.042	6	.923	.048	6	1.234	.149	6	2.880	.330
5/ 9/63	300	6	1.024	.041	5	.966	.049	5	1.216	.238	5	2.800	.480
5/ 9/63	700	6	1.032	.030	5	.965	.024	5	1.291	.232	5	2.720	.350

S/S* - OBSERVED/PREDICTED SYSTOLE
I/I* - OBSERVED/PREDICTED ISOTONIC PHASE
M/M* - OBSERVED/PREDICTED ISOMETRIC PHASE
I/M - HEMODYNAMIC RATIO

TABLE A3 (continued)

AVERAGE VALUES OF OBSERVED/PREDICTED RATIOS OF CARDIAC DYNAMICS

STUDY I - PERIOD 2

DATE	TIME	S/S* N	S/S* MEAN	S/S* S.D.	I/I* N	I/I* MEAN	I/I* S.D.	M/M* N	M/M* MEAN	M/M* S.D.	I/M N	I/M MEAN	I/M S.D.
5/20/63	1900	6	.963	.028	5	.926	.033	5	1.104	.143	5	3.130	.280
5/20/63	2300	6	.970	.040	5	.954	.044	5	1.086	.137	5	3.050	.300
5/21/63	300	6	1.014	.041	6	.994	.034	6	1.088	.190	6	3.090	.420
5/21/63	700	6	.995	.024	6	.971	.045	6	1.088	.213	6	3.000	.490
5/21/63	1100	6	.992	.028	6	.941	.033	6	1.189	.137	6	3.020	.350
5/21/63	1500	6	.954	.018	6	.956	.051	6	.952	.166	6	3.650	.820
5/21/63	1900	6	.958	.019	3	.937	.028	3	1.066	.207	3	3.160	.360
5/21/63	2300	6	.964	.034	5	.928	.047	5	1.020	.218	5	2.280	1.900
5/22/63	300	6	.999	.042	6	.951	.034	6	1.161	.178	6	2.690	.310
5/22/63	700	6	1.014	.026	5	.941	.038	5	1.260	.184	5	2.640	.260
5/22/63	1100	6	.993	.015	6	.929	.044	6	1.257	.204	6	2.940	.460
5/22/63	1500	6	.952	.050	6	.893	.067	6	1.208	.199	6	2.980	.340
5/22/63	1900	6	.959	.031	6	.903	.048	6	1.184	.224	6	2.980	.610
5/22/63	2300	6	.990	.032	6	.924	.072	6	1.226	.294	6	2.810	.740
5/23/63	300	6	.995	.034	6	.971	.055	6	1.094	.294	6	3.150	1.110
5/23/63	700	6	1.019	.034	6	.957	.045	6	1.259	.247	6	2.790	.440

S/S* - OBSERVED/PREDICTED SYSTOLE
I/I* - OBSERVED/PREDICTED ISOTONIC PHASE
M/M* - OBSERVED/PREDICTED ISOMETRIC PHASE
I/M - HEMODYNAMIC RATIO

T A B L E A3 (continued)

AVERAGE VALUES OF OBSERVED/PREDICTED
RATIOS OF CARDIAC DYNAMICS

STUDY II - PERIOD 1

DATE	TIME	N	S/S* MEAN	S/S* S.D.	N	I/I* MEAN	I/I* S.D.	N	M/M* MEAN	M/M* S.D.	N	I/M MEAN	I/M S.D.
7/19/63	1212	6	.985	.030	6	.972	.031	6	1.039	.235	6	3.470	.730
7/20/63	1305	2	1.010	.069	2	.989	.027	2	1.088	.217	2	2.990	.020
7/21/63	850	6	.969	.046	5	.958	.047	5	.987	.189	5	3.530	.860
7/21/63	2127	1	.986	.000	1	.996	.000	1	.948	.000	1	3.900	.000
7/22/63	720	6	1.015	.035	5	.992	.049	5	1.138	.200	5	3.260	.550
7/22/63	1920	6	.973	.030	6	.961	.033	6	1.020	.198	6	3.620	.760
7/23/63	730	6	.996	.050	6	.981	.031	6	1.053	.192	6	3.220	.430
7/23/63	1910	6	.963	.044	6	.920	.026	6	1.120	.222	6	3.120	.620
7/24/63	715	6	.954	.049	6	.952	.042	6	.964	.112	6	3.280	.300
7/24/63	1919	6	.927	.035	6	.924	.065	6	.937	.226	6	3.850	1.290
7/25/63	725	6	.967	.051	6	.935	.022	6	1.080	.173	6	2.970	.270
7/25/63	2030	6	.941	.050	6	.889	.029	6	1.146	.318	6	3.010	.690
7/26/63	725	6	.988	.063	6	.954	.037	6	1.109	.196	6	2.980	.340
7/26/63	1900	6	.969	.050	6	.900	.024	6	1.274	.370	6	2.950	.560
7/27/63	740	6	.966	.062	5	.923	.018	5	1.037	.165	5	3.000	.160
7/27/63	1907	6	.913	.044	6	.874	.042	6	1.074	.296	6	3.300	.990
7/28/63	710	5	.980	.059	6	.934	.012	5	1.145	.214	6	2.140	1.560
7/28/63	1500	6	.938	.036	6	.895	.027	6	1.094	.120	6	2.920	.280
7/28/63	1920	6	.951	.038	6	.927	.054	6	1.040	.137	6	3.390	.740
7/28/63	2300	5	.953	.043	6	.923	.029	5	1.034	.146	6	2.410	1.680
7/29/63	310	6	.997	.053	6	.961	.027	6	1.118	.187	6	2.840	.330
7/29/63	725	6	.965	.050	6	.957	.035	6	.993	.171	6	3.260	.500
7/29/63	1105	6	.939	.043	6	.908	.048	6	1.053	.165	6	3.170	.620
7/29/63	1512	6	.932	.038	6	.926	.021	6	.955	.112	6	3.420	.160

S/S* - OBSERVED/PREDICTED SYSTOLE
I/I* - OBSERVED/PREDICTED ISOTONIC PHASE
M/M* - OBSERVED/PREDICTED ISOMETRIC PHASE
I/M - HEMODYNAMIC RATIO

T A B L E A3 (continued)

AVERAGE VALUES OF OBSERVED/PREDICTED RATIOS OF CARDIAC DYNAMICS

STUDY II - PERIOD 1

DATE	TIME	S/S* N	S/S* MEAN	S/S* S.D.	I/I* N	I/I* MEAN	I/I* S.D.	M/M* N	M/M* MEAN	M/M* S.D.	I/M N	I/M MEAN	I/M S.D.
7/29/63	1910	6	.956	.055	6	.902	.033	6	1.203	.330	6	3.040	.380
7/29/63	2310	6	.989	.066	6	.955	.025	6	1.123	.243	6	2.970	.300
7/30/63	320	5	.992	.055	5	.967	.060	5	1.076	.167	6	3.190	.660
7/30/63	718	6	.964	.059	6	.929	.038	6	1.092	.183	6	2.950	.330
7/30/63	1910	5	.946	.033	6	.909	.057	5	1.057	.184	6	2.750	2.000
7/31/63	710	6	.983	.055	6	.970	.033	6	1.030	.147	6	3.140	.260
7/31/63	1927	4	.992	.023	6	.886	.066	4	1.402	.503	6	1.550	2.070
8/ 1/63	715	6	.991	.055	6	.956	.038	6	1.113	.143	6	2.870	.270
8/ 2/63	715	6	.972	.065	6	.949	.031	6	1.051	.211	6	2.990	.460
8/ 2/63	1900	6	.941	.047	6	.890	.045	6	1.136	.197	6	3.160	.820
8/ 3/63	720	6	.982	.052	6	.957	.036	6	1.070	.149	6	3.030	.340
8/ 3/63	1905	5	.957	.052	6	.897	.036	5	1.239	.334	6	2.410	1.770
8/ 4/63	704	6	.980	.047	6	.946	.028	6	1.100	.166	6	2.880	.350
8/ 4/63	1920	6	.937	.053	6	.899	.024	6	1.092	.249	6	3.140	.610
8/ 5/63	713	6	.997	.047	6	.959	.028	6	1.140	.162	6	3.170	.580
8/ 5/63	1925	6	.958	.048	6	.927	.031	6	1.083	.257	6	3.360	.640
8/ 6/63	712	6	.988	.047	6	.974	.027	6	1.038	.144	6	3.350	.380
8/ 7/63	715	6	1.027	.049	6	1.006	.032	6	1.104	.140	6	3.200	.340
8/ 7/63	1908	6	1.015	.068	6	.965	.012	6	1.247	.309	6	3.230	.430
8/ 8/63	725	6	1.040	.058	6	1.026	.026	6	1.097	.196	6	3.430	.450
8/ 8/63	1900	6	1.036	.051	6	.985	.030	6	1.266	.272	6	3.300	.390
8/ 9/63	715	6	1.051	.043	6	1.029	.048	6	1.130	.106	6	3.280	.420

S/S* - OBSERVED/PREDICTED SYSTOLE
I/I* - OBSERVED/PREDICTED ISOTONIC PHASE
M/M* - OBSERVED/PREDICTED ISOMETRIC PHASE
I/M - HEMODYNAMIC RATIO

T A B L E A3 (concluded)

AVERAGE VALUES OF OBSERVED/PREDICTED
RATIOS OF CARDIAC DYNAMICS

STUDY II - PERIOD 2

DATE	TIME	S/S* N	S/S* MEAN	S/S* S.D.	I/I* N	I/I* MEAN	I/I* S.D.	M/M* N	M/M* MEAN	M/M* S.D.	I/M N	I/M MEAN	I/M S.D.
8/15/63	1850	6	.992	.077	6	.978	.044	6	1.056	.256	6	3.650	.600
8/17/63	715	6	.973	.061	6	.985	.050	6	.931	.125	6	3.450	.390
8/17/63	1850	6	.995	.058	6	.967	.025	6	1.126	.305	6	3.570	.540
8/20/63	922	6	.940	.048	6	.957	.084	6	.938	.551	6	5.480	4.010
8/20/63	1855	6	.929	.071	6	.897	.053	6	1.065	.302	6	3.190	.630
8/22/63	720	6	.951	.050	6	.956	.043	6	.934	.113	6	3.360	.400
8/22/63	1850	6	.917	.052	6	.904	.036	6	.978	.312	6	3.560	.950
8/26/63	855	6	.908	.044	6	.896	.035	6	.952	.204	6	3.420	.760
8/27/63	720	6	.954	.074	6	.946	.059	6	.980	.221	6	3.330	.730
8/27/63	1855	6	.938	.051	6	.924	.022	6	1.010	.300	6	3.710	.850
8/28/63	730	6	.958	.051	6	.955	.014	6	.972	.191	6	3.290	.570
8/28/63	1905	6	.924	.057	6	.885	.044	6	1.089	.349	6	3.220	.760
8/29/63	710	5	.956	.063	5	.926	.032	5	1.055	.209	5	2.940	.500
8/29/63	1845	6	.916	.053	6	.885	.042	6	1.055	.345	6	3.310	.720
8/30/63	732	6	.965	.053	6	.929	.031	6	1.090	.184	6	2.980	.540
8/30/63	1855	6	.949	.057	6	.900	.045	6	1.151	.281	6	3.050	.560
8/31/63	915	6	.972	.058	6	.914	.031	6	1.221	.357	6	3.140	.740
8/31/63	1905	6	.952	.062	6	.891	.039	6	1.233	.502	6	3.200	1.050
9/ 1/63	920	5	.965	.059	5	.910	.039	5	1.215	.432	5	3.230	.880
9/ 1/63	1901	5	.944	.063	5	.889	.019	5	1.174	.363	5	3.080	.750
9/ 2/63	657	5	.982	.061	5	.939	.037	5	1.135	.160	5	2.890	.230
9/ 3/63	725	4	.996	.050	4	.974	.031	4	1.073	.156	4	3.290	.470
9/ 4/63	715	4	.974	.029	4	.969	.035	4	.989	.129	4	3.370	.600
9/ 5/63	730	4	1.002	.047	4	.997	.029	4	1.021	.154	4	3.500	.530

S/S* - OBSERVED/PREDICTED SYSTOLE
I/I* - OBSERVED/PREDICTED ISOTONIC PHASE
M/M* - OBSERVED/PREDICTED ISOMETRIC PHASE
I/M - HEMODYNAMIC RATIO

NASA-Langley, 1965 CR-179